that occurred in the orchards near Logan, Utah, during the same period.

(3) Ben Davis apple buds in full bloom have experienced temperatures of 25°, 26°, and 27° F., without injury, but 28° usually kills about one-fifth. Twenty-nine degrees or above are safe temperatures. Twenty-five degrees kills about one-half and 22° about nine-tenths. On several occasions, however, apples matured on branches that experienced 20° when the buds were in full bloom.

(4) With Elberta peach buds in full bloom, 29° F., or above, are the safe temperatures, because even though occasionally 26°, 27°, and 28° do no damage, yet on most occasions 28° will kill from one-fourth to one-half. Twenty-six degrees kills about one-half of them and 22° about nine-tenths. Temperatures as low as 18° have failed to kill all of them.

(5) With sweet cherry buds in full bloom, 30° F. is the safe temperature; 25°, 26°, 27°, 28° have done no damage; but 29° usually kills about one-fifth. Twenty-five degrees usually kills about one-half, and when the buds were showing color 22° killed only two-fifths of the buds.

(6) Sour cherries are hardier than the sweet varieties. When the buds were showing color 23° did not harm them, and when they were in full bloom 26° killed but one-fifth and 22° only two-fifths of them.

(7) With apricots 29° is the safe temperature; 26° and 27° killed about one-fifth and 22° killed one-half. They are fairly hardy, but they bloom so early that they are frozen oftener than any of the other fruits studied in the experiments.

(8) The foregoing figures refer to the buds when in full bloom. Starting from this stage, the earlier the stage of development the hardier the buds are; and in general, when the fruit is setting the injury is from 5 to 10 per cent more than when they are in full bloom.

(9) Sour cherries are the hardiest, and then follow in order apples, peaches, apricots, and sweet cherries.

(10) The fact that the same branch of buds will on one occasion experience 27° with 25 per cent injury and on another occasion take the same temperature with no injury is no doubt due to the fact that the juice is contained in capillary cells and supercooling results—that is, the buds are cooled below the freezing point of the juice without the freezing taking place. The great difficulty of killing all the buds even at extremely low temperatures is due to the same cause, together with the fact that the cell sap may be very concentrated. Differences in the hardiness of the different kinds of buds and also of the same buds at different stages of development is due to differences in quality and concentration of the cell sap.

551.578.7 (782)

SEVERE HAILSTORM IN NEBRASKA.

HARRY G. CARTER, Meteorologist.

[Weather Bureau, Lincoln, Nebr., Dec. 22, 1920.]

On Friday, July 16, 1920, there occurred in Antelope and Boone Counties, in northeastern Nebraska, an unusually severe hailstorm.

The center of the path of greatest destruction extended from south of Royal and Brunswick, in Antelope County, to a point just east of Neligh, thence southward directly through Oakdale, east of Elgin, Petersburg, Loretto, Albion, and Boone, through St. Edward and between Fullerton and Genoa to the Platte River, a distance of nearly 70 miles. The area over which hail fell varied from 1 mile to 6 miles in width. No reports were received of hail from stations south of the Platte River.

In the area of greatest destruction portions of farms were swept nearly clear of vegetation. Small grain was pounded flat to the ground and some fields were left nearly bare, and in places it was difficult to tell just what crop had occupied the field before the storm struck. Here and there nothing remained of corn but battered stalks from a few inches to a few feet in height. Trees were divested of foliage and bark stripped off on the side facing the storm. The high wind uprooted trees and wrecked farm buildings, while the hail broke nearly all the windows on the north side of farm houses and buildings and many on the east side, besides damaging many roofs so badly that the rain poured through and damaged the interior. An excessive downpour caused a few streams to overflow their banks so that in places the devastated region suffered loss from floods in addition to loss from hail and wind.

Some farmers in the stricken region lost a large portion of their growing crops. A few sowed millet, cane, or buckwheat in their storm-swept fields. A number found it necessary to dispose of their surplus hogs and cattle as it was impossible to provide feed for them.

The greatest damage occurred in the region adjacent to Oakdale, in Antelope County. North of Oakdale but a relatively small area suffered loss, while to the southward from Oakdale to a point nearly east of Albion, in Boone County, there was considerable damage to various crops. East of Albion the hailstones were smaller, the wind velocity less, the rain fell at a slower rate, and the damage to crops was consequently less than to the northward. From here southward the storm gradually decreased in intensity, and south of the Platte River no hail was reported.

The hail was an accompaniment of a thunderstorm of unusual severity. The wind at places approached hurricane strength, but at no time was there any indication of tornadic action, the damage by the wind in every case reported being the result of a straight blow. All reports state that the greatest damage to buildings by hail was on the north side, although at some places the east side suffered nearly equal damage.

The hailstones varied in size from ½ inch to more than 2½ inches in diameter, and were mostly round. Some observers, however, reported hailstones that were "flattened spheres" and "irregular chunks of ice." The surfaces of the hailstones were mostly smooth, although some were rough. No marked protuberances were noticed.

The hail began to fall soon after the beginning of the rain, the interval varying from a few minutes to more than 30 minutes, the average time being somewhat less than 15 minutes. Rain fell from 30 minutes to 2½ hours, the time being less and the rate of fall greater in the northern portion of the area. Hail fell from 15 minutes to an hour, at most places the time being less than 30 minutes. It continued longer in the southern end of the belt than in the northern.

Neligh was on the western edge of the storm. Here rain fell from 2:50 p. m. to 3:20 p. m., and although hail fell for 20 minutes (from 3 p. m. to 3:20 p. m.) the hailstones were not unusually large and caused no material

damage in the city, although crops were damaged 1 mile to the east, the damage extending over an area from 1 mile to 3 miles in width. A high wind accompanied the storm and trees were uprooted and telephone and electric light wires were blown down by the wind or carried down by falling branches of trees. A rainfall of 2.13 inches was recorded in 30 minutes, flooding the town. A race meet was in progress when the storm struck, and so suddenly did the storm come up that none of the people in the park had a chance to leave. A big tent and many booths and a ferris wheel belonging to a carnival company were wrecked, but no lives were lost.

The storm had increased in intensity by the time it struck Oakdale at 3:15 p. m. Here 5.80 inches of precipitation, including rain and melted hail, fell in 45 minutes, turning streets into raging rivers several feet deep in places and flooding nearly every basement in the business part of the town, the water even running into the street doors of some of the stores. The municipal water plant was flooded and was shut down until 3 p. m. Sunday, the 18th. Hailstones from 1 inch to more than 2½ inches in diameter fell for 25 minutes. Nearly all the windows on the north and east sides of buildings and houses were broken. Holes were pounded in roofs and rain poured through in torrents, flooring the interiors. Trees were stripped of foliage and bark peeled off on the side facing the storm. A gale uprooted trees and broke telephone and electric light wires.

It was in this territory that crops suffered the greatest damage. Over a strip from 3 to 5 miles in width the destruction was nearly complete. Hailstones accumulated in drifts to a considerable depth. Authentic reports were received of hailstones lying in drifts several feet deep in protected places, requiring a number of days to melt.

A passenger train on the Northwestern Railroad leaving Oakdale at 2:50 p. m. was caught in the storm between Oakdale and Neligh and most of the windows on the north side of the train were broken.

South of Oakdale the storm decreased in intensity. At Closter, 14 miles south of Oakdale and 10 miles east of Petersburg, crops were damaged over an area about 6 miles in width, and while losses were considerable the destruction was not as complete as at Oakdale. No authentic measurements of hailstones were made, but a newspaper report mentioned the hailstones as "huge chunks of ice swept with deadly force by a high wind." Rain fell from 3 p. m. to 3:30 p. m.

East of Albion the path of the storm was 6 miles wide. Rain fell from 3 p. m. to 3:35 p. m., and hail fell for 15 minutes, beginning at 3 p. m. The largest hailstones were the size of dove eggs, although most of the hailstones were the size of bird eggs.

At Boone rain fell from 4 p. m. to 6:30 p. m., and hail from 4:15 p. m. to 5 p. m., the hailstones being the size of marbles.

At the southern end of the hail-swept area, about 8 miles north of the Platte River, rain did not begin to fall until 5 p. m. and ended at 6 p. m. Hail began to fall very soon after the beginning of the rain and continued 45 minutes, the largest hailstones being the size of goose eggs and doing considerable damage to crops.

The rain did not begin over the entire region at the same time, but began at the north end first. A line passing through places where the rain began simultaneously runs in a northeast-southwest direction. The rain area spread southeastward rather than straight southward.

It is thought this unusually severe thunderstorm did not move from the north to the south. It is more likely that it moved eastward with a front extending from northeast to southwest, the rain beginning along the entire front at nearly the same time. This would account for the northeast-southwest line of simultaneous beginning.

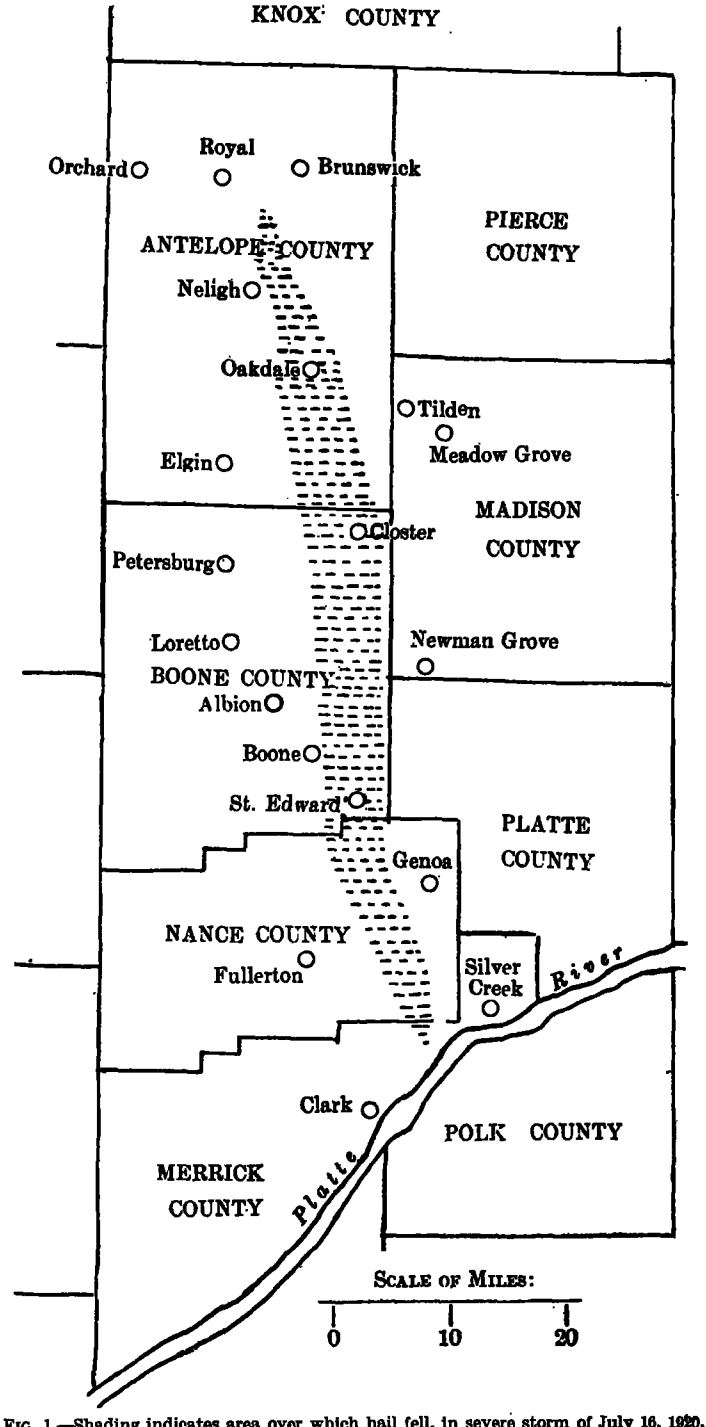

FIG. 1.—Shading indicates area over which hail fell, in severe storm of July 16, 1920, in eastern Nebraska. Growing crops were damaged more or less over a considerable portion of this area, and in places were completely destroyed.

Hail began to fall at all places in the northern half of the belt at nearly the same time, but over the southern half it began later and later as it spread southward, and at the southern end of the belt hail began 2 hours later than at the northern end.

It is very probable that hail was formed first on the extreme front side of the thunderstorm and gradually spread southwestward along its front. As the thunder-

storm moved eastward the hail-forming area was moving southwestward along its front. The ratio of the two movements was such that the resultant was a southerly movement of the hail-forming area. This would give the appearance of a hailstorm moving in a straight southerly direction. Had either the thunderstorm moved eastward at a different speed or the hail-forming area moved southwestward along its front at a different rate, the path of the hailstorm would have not been straight north and south.

The fall of hail continued longer in the southern end of the area than in the northern. This may be explained by the gradual weakening and slower spreading of the hail-forming area, together with a slower eastward movement of the thunderstorm. As the thunderstorm weakened it moved slower, and consequently the hail-forming area was over a unit of area longer than it was earlier in its course, when the movement of the thunderstorm was more rapid.

The weather map on the morning of the 16th was relatively "flat." The pressure was quite uniformly between 30 and 30.2 inches over the entire country, except over New England, western Idaho, Arizona, and the southern California coast. The highest pressure was 30.2 inches at Moorhead, N. Dak. During the day a slight depression developed over Nebraska and at 7 p. m. a LOW of 30 inches was central over the State. Thunderstorms were general during the day over a strip about a hundred miles wide, extending across the entire length of the State. The amounts of precipitation were light in the western half of the State, averaging mostly less than a quarter of an inch. In the eastern half the rainfall was heavier, ranging from a quarter of an inch to the excessive downpour of 5.80 inches at Oakdale. Along the Missouri River, except in the northeast corner of the State, the rainfall was light, and in the extreme southeastern counties no rain fell.

THE R.34 DESTROYED IN A GALE.

News has been received with regret that the great British dirigible, the R. 34, which so successfully crossed the Atlantic in July, 1919, was destroyed on January 28 at its base station at Howden, England, while endeavoring to reach its hangar in a gale. Having gone out on a practice cruise with the R. 32 the previous day, intending to return the same afternoon, through some misfortune in landing, two propellors were broken and three of the five engines put out of commission. With a 34-mile wind blowing, the dirigible was forced in a practically helpless condition some distance out to sea, but was able eventually to make some headway toward its base by means of the two remaining engines. Upon arriving at Howden an attempt was made to place it in its hangar, but the efforts of several hundred men were not effective in restraining it against the increasing wind. This wind, making gusts and eddies about the hangar, caused the ship to pitch in such a manner that several of the gondolas were smashed and the internal girder structure weakened to the breaking point. With the collapse of the rigid framework and the consequent piercing of the gas bags, the airship was practically destroyed. While mooring masts are yet in the experimental stage, it appears that in tests recently made, large rigid airships have outridden storms of as great severity as this with no damage whatsoever and without the aid of a large ground party. It is unfortunate indeed that this famous and costly ship could not have had access to such a mooring mast. While it is apparent that the reasons underlying the destruction of this ship are mechanical and could probably have been overcome with adequate equipment, such as that mentioned above, yet it furnishes a noteworthy example of the effect of weather upon aircraft and the importance of neglecting no opportunity to take account of this factor.—*C. L. M.*

551.583

ARE THE SEASONS CHANGING?

By CLARENCE J. ROOT, Meteorologist.

[Weather Bureau Office, Springfield, Ill.]

It is probably the experience of every Weather Bureau official to hear remarks similar to this: "The seasons are changing. We do not have the cold weather we did when I was a boy." With the exception of a few months in 1795, continuous temperature records have been maintained at New Haven, Conn., since February, 1780. The data used in this discussion were taken from the records of various observers from 1778 to 1872 and from those of the Weather Bureau station at New Haven from 1873 to the present.[1] The writer has averaged the annual mean temperature values by decades, with the following results:

For the 10 years ending—	Mean temperature (F.), degrees and tenths.
1790	49.6
1800	50.0
1810	50.4
1820	47.5
1830	49.3
1840	47.8
1850	49.2
1860	48.9
1870	49.1
1880	49.7
1890	48.9
1900	49.7
1910	49.7
1920	50.5

It will be noted that the warmest three periods are those ending in 1800, 1810, and 1920, and that the coldest decade immediately follows the second warmest.

Considering the individual months and the individual years, it is found that the coldest January occurred as late as 1857. The coldest February occurred 8 years after the warmest one. The coldest March was as late as 1870 and again in 1885. The coldest April was in 1874, and many years after the warmest one. In May we find a number of years with the same lowest temperature—1812, 1815, 1870, and 1882. The highest figures in June are in 1779, 1790, 1803, and 1876. In July the lowest was in 1816, with the warmest as early as 1780 and as late as 1876. The coldest August occurred 61 years after the warmest. In September the coolest months are in the earlier years, but for October, November, and December the coldest year came after the warmest year in each case.

Thus it will be seen that in nine months of the year the coldest one of record occurred after the warmest one. These figures seem to indicate very clearly that since the time of the Revolutionary War, at least, there has been no permanent change in temperature.

[1] The earlier observations are published in the *Transactions of the Connecticut Academy of Sciences*, vol. 1; they are summarized and combined with the Weather Bureau records in the *Annual Meteorological Summary for 1920*, published by the Weather Bureau office at New Haven, Conn.